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by Karen Orzechowski Signature: Karen Orzechowski

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

In re application of B. M. Bass, et al.	:	January 21, 2005 IBM Corporation - 9CCA/B002
	:	P.O. Box 12195
Serial No. 09/544,992	:	Research Triangle Park, North Carolina 27709
Filed: April 6, 2000	:	
	:	Unit: 2172
For: LONGEST PREFIX MATCH (LPM) ALGORITHM IMPLEMENTATION FOR A NETWORK PROCESSOR	: : :	Examiner: Anh LY

APPEAL BRIEF

Mail Stop Appeal Brief- Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This is an appeal from the Final rejection of claims 14-24 of this application. An appendix containing a copy of the rejected claims is attached.

I. REAL PARTY IN INTEREST

The real party in interest is International Business Machines Corporation (IBM), Assignee of the present application.

II. RELATED APPEALS AND INTERFERENCES

None.

III. STATUS OF CLAIMS

Claims 25-34 and 52-59 are withdrawn from examination as a result of restriction by the Examiner.

Claims 1-13 and 35-51 are allowed.

Claims 14-24 are appealed.

IV. STATUS OF AMENDMENT

No amendment has been filed subsequent to the Final Rejection.

V. SUMMARY OF INVENTION

The present invention relates to a data structure for determining Longest Prefix Match (LPM) search. In such search the idea is to find the longest match between a variable length pattern or prefix also known as a key and predefined patterns. The result is used for routing packets within communications networks. Such networks may

include private networks (intranet), public network (Internet, also called -WWW- WorldWide Web) or combination of both. One of the major problems experienced by users of these networks is delays associated with determining a path interconnecting Source and Destination stations within the network.

This invention describes a novel data structure for longest prefix match search, which provides the mechanism for searching tables efficiently with variable length patterns or prefixes. This approach allows a very efficient and simple implementation with the least amount of storage and search time. In modern communications networks, it is very important to identify the best match prefix very quickly due to the speed and volume of traffic. An example is the IP layer 3 forwarding table. Typically, when a forwarding engine is looking for a given IP address/key, the matching result could be full match/exact match for a host address or it could be a prefix for a network address. Summary of the Invention at pages 10 through 12, appellants' specification.

Figures 5, 7 and 9 show data structure according to teachings of the present invention. The data structure includes a pattern or key (102, Fig. 5) to be searched, Direct Table (108), a plurality of Pattern Search Control Blocks (PSCB 110, 114 and 112) operatively coupling DT 108 to a plurality of leaves 116, 118, 120 and 122. Appellants' Specification, page 26, lies 8-18 and page 31, lines 10-20.

Figure 9 shows an example of a data structure for a Longest Prefix Match (LPM) tree having Direct Table (DT), Pattern Search Control Block (PSCB), at least one Bird and leaves (L1- L3). Appellants Specification, page 48, line 19 through page 51.

Figure 6 shows benefits derived from use of a Direct Table in the data structure. The depth (i.e. number of Nodes, Pattern Search Control Blocks, traversed in a search) of the tree is reduced by use of the Direct Table 108. Stated another way, by using a Direct Table fewer nodes are traversed when conducting a search; the delay associated with a search directly relates to the number of nodes or PSCB traverse. The

fewer the number of PSCBs traverse the shorter the search time. With reference to Figure 6, the drawing on the left represents a data structure without a Direct Table. Whereas the drawing on the right represents a Data Structure with a DT. With a DT fewer nodes (PSCBs) are traversed resulting in a shorter search time. Appellants' Specification page 38, line 9 through page 39, line 3.

VI. ISSUES

The appeal presents a single issue, to wit:

Whether claims 14-24 are patentable, under 35 USC 103(a), over U.S. Patent No. 6,553,002.

VII. GROUPING OF CLAIMS

The appeal presents a single group, consisting of claims 14-24, which do not stand or fall together.

VIII. ARGUMENTS

Claims 14-24 are rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 6,553,002 issued to Bremer et al.

To support a rejection under 35 USC 103(a) the Examiner is obliged by law to establish a prima facie case of obviousness. To do so the prior art reference, among other things, must teach or suggest all the claim limitations. MPEP 2142.

A. ALL CLAIM LIMITATIONS NOT TAUGHT OR SUGGESTED IN U.S. PATENT NO. 6,553,002

Claim 14, sole independent claim, among other things, calls for (a) " . . . a direct table that stores a first address location for a search tree;" and (b) "at least one bird representing a partial match of the input key".

None of the elements (a or b) is found or suggested in U.S. Patent No. 6,553,002 which teaches a routing table stored as a search tree also known as a search trie to produce the address of a router in path to which a data packet is to be set. Bremer et al. col. 2, lines 56-59. There is no teaching or suggestion for a "Direct Table (DT)" and/or "Bird" in combination with a search tree as recited in claim 14. As a consequence even after the Examiner's modification of Bremer et al. the recited elements would be absent. Therefore, the Examiner fails to make out a prima facie case of obviousness.

B. NOVEL STRUCTURE AND BENEFITS ARE EVIDENCE OF NONOBVIOUSNESS

As argued above and incorporated herein by reference (a) and/or (b) –identified in A. above– are not suggested in Bremer et al. As a consequence appellants argue the structure of claim 14 is novel.

As argued with respect to Figure 6 (see Summary of Invention, above) use of the

Direct Table reduces search time and hence the delay associated with searches. The reduction of search time is a benefit to users.

In addition, the "Bird" as recited in claim 14 also provides benefits in that it can be used to find a subnet for a Long Prefix Match (LPM) search. Appellants' Specification page 49, line 16 through page 51, line 3. This feature is not taught or recognized in Bremer et al.

As a consequence the novel structure and benefits and/or functions derived from the claimed invention are evidence of nonobviousness. Therefore, claim 14 is not obvious.

C. RESPONSE TO EXAMINER'S CONTENTION

The Examiner seems to contend the Direct Table (DT) and "Bird" as set forth in Appellants' claim 14 are suggested in Bremer. In particular with respect to teachings for "Direct Table" and Bird the Examiner states: "Bremer discloses a routing table stores a search tree or search tree producing the address or location or a router as direct table (col. 2, lines 58-62 and col. 4, lines 50-52; see fig. 14A and fig. 14B); and a leaf node of the search tree as a bird (col. 7, lines 40-44)." Final Office Action, paper #19, page 4, last paragraph.

In response, appellants respectfully disagree with the Examiner and argue the routing table in Bremer et al. is not the equivalent of the Direct Table set forth in claim 14. In Bremer et al. the routing table does not include a Direct Table as set forth in claim 14. Instead in Bremer the routing table is a "search tree" also known as a "search trie". Bremer et al. col. 2, lines 56-60 and col. 5, lines 3-7.

It is appellants' contention no reasonable construction of Bremer would suggest

the data structure of a Direct Table in combination with tree structure as set forth in claim 14 when Bremer et al. indicates routing table as a tree structure.

To do so runs against the grain of the teachings in Bremer and would suggest a modification based upon hindsight gleaned from appellants' disclosure and not on foresight based upon teachings of the reference.

Likewise, appellants contend the Examiner relying on the teaching of mask bits stored in a leaf node to suggest "Bird" as stated in appellants' claim 14 appears to be error. This is error because leaf node as shown and taught in Bremer relates to end node only. Stated another way a leaf node according to teaching in Bremer is the last node encountered after a tree walk. See Bremer, col. 7, lines 58 through col. 8, lines 45, Fig. 7 (elements 84a-87a) and Fig. 8, element 89a. There is no teaching or suggestion in Bremer that the leaf node could be placed at a location other than the end of a search path.

"Bird" as used in claim 14 means a leaf located internal to the search path but not at the end. See appellants' specification page 41, line 11 through page 42, line 21; page 48, line 19 through page 51, line 3 and Fig. 9.

Because leaf node as use in Bremer and Bird as used in claim 14 are different concepts and feature the teachings in Bremer would not suggest to an artisan the modification that would render claim 14 obvious.

In fact, appellants agree this difference suggests a "Teach Away" from claim 14 which is further evidence of nonobviousness.

Since there is no other teaching of "Bird" other than appellants' own disclosure it would appear the modification to the prior art (Bremer) is based upon information gleaned from appellants' disclosure. Accordingly, appellants contend that which is disclosed by the inventor should not be used to modify the prior art in order to meet the

claimed invention.

Furthermore, appellants argue "Bird" should be construed in accordance with its construction or definition set forth in the document in which it originated. In this case Bird should be construed according to appellants' specification. It is often said the patentee is his/her own lexiographer. This means the appellants can assign specific characteristics to a word provided the characteristics are set forth in the specification. As argued above and incorporated herein by reference Bird is clearly defined with specific characteristics –in the appellants' specification– which should be used as the standard for assessing obviousness under 35 USC 103(a). Since the characteristics of "leaf node" (Bremer) teaches away from "Bird" claim 14 is nonobvious and patentable over Bremer.

D. Patentability of Claim 15

Claim 15, due to dependency on claim14, is patentable for reasons set forth above and incorporated herein by reference.

In addition, claim 15 is separately patentable.

Claim 15 –depends on claim 14– calls for a lookup definition table (LUDT) that manages a tree search memory. The LUDT is in addition to elements of claim 14. The LUDT is shown in Figure 12 and described at page 29, lines 12-22. An LU Def Index (lookup definition index) 8 bits are used to access the LUDT. Appellants' specification page 28, lines 9-14. The LUDT stores information for building and searching tree structures. The hardware uses this information to build and/or search a tree in a relatively short time interval. This is a benefit to the user. The structure is also novel. It is appellants' contention novel structure and benefits are evidence of nonobviousness.

With respect to claim 15 the Examiner relied on teachings set forth at Bremer col. 4, lines 47-52. See Final Office Action Paper #19, page 51.

In response, appellants contend the teaching at col. 4, lines 47-52 relates to routing table to determine next router to which a packet is to be sent while on its way to destination host. This teaching is different from that of a lookup table that manages tree structure. As a consequence the teaching of Bremer would not suggest appellants' claim 15. Therefore, claim 15 is patentable over Bremer.

In addition, it seems the Examiner relied on the teaching at col. 4, lines 47-52 (Bremer) to support his position that "Direct Table . . . " appellants' claim 14 is suggested in Bremer[1]. Claim 15 –by reason of its dependency on claim 14– includes the Lookup Definition Table together with elements including the Direct Table set forth in claim 14. It seems the Examiner relied on the same teaching in Bremer to meet two elements of appellants' claim 15. By relying on the same teaching at col. 4, lines 47-52 (Bremer) to meet two elements of claim 15, appellants contend a prima facie case of obviousness is not made. Therefore, claim 15 is nonobvious.

E. Patentability of Claim 16

Claim 16 – by reason of its dependency on claim 15– is patentable for reasons set forth above and incorporated herein by reference.

In addition, claim 16 is separately patentable. Claim 16 requires entries in the Definition Lookup Table to define a physical memory that the tree resides in, size of key

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[1]It should be noted appellants do not agree with the Examiner and arguments traversing this position are set forth above.

and leaves and type of search to perform.

Listing the recited characteristics enable the hardware to use less time to complete a tree search and, therefore, reduce delay associated with tree structures. This benefit is further evidence of nonobviousness.

Regarding claim 16, the Examiner relied on teachings at col. 4, lines 66 through col. 5, line 32 (Bremer) to support the rejection.

Appellants have reviewed Bremer including the portions identified by the Examiner and could not find any suggestion of a Lookup Definition Table with entries partitioned as set forth in claim 16. As a consequence it seems the Examiner misconstrued the teachings of the reference and reached an erroneous conclusion.

F. Patentability of Claim 17

Claim 17, due to dependency on claim 15, is patentable for reasons set forth above and incorporated herein by reference.

In addition, claim 17 is separately patentable. Claim 17 calls for the lookup definition table to be implemented in a plurality of memories. Because the lookup definition table is in multiple memories, they can be search simultaneously to provide information in relatively short time intervals. Appellants' specification page 29, lines 19-22. This benefit provides indicia of nonobviousness.

With respect to claim 17 the Examiner relied on teachings at col. 10, lines 22-38 of Bremer. See Final Office Action, Paper #19, page 5. A review of the section indicates the teaching relates to leaf node data structure 115 (Fig. 11). A teaching of multiple memories as stated in claim 17 could not be found in Bremer.

G. Patentability of Claim 18

Claim 18, due to dependency on claim 14, is patentable for reasons set forth above and incorporated herein by reference.

In addition, claim 18 is separately patentable. Claim 18 states a format for an entry in the Direct Table (DT). The format includes at least one of several items –recited in the claim– be placed in the entry. By doing so the time to complete a search is shortened because the entry may contain the answer, thus making a 'tree walk' unnecessary.

With respect to Examiner's arguments, –page 5 Final Office Action Paper #19– supporting rejection of claim 18 appellants contend Bremer does not teach a Direct Table. Therefore, there would be no need or reason to teach a format for entry in a structure (Direct Table) not suggested or relevant to the reference. Arguments set forth above supporting appellants' position on this issue are equally applicable and are incorporated by reference.

H Patentability of Claim 19

Claim 19 stands or falls with claim 14.

I Patentability of Claim 20

Claim 20 stands or falls with claim 14.

J. Patentability of Claim 21

Claim 21 is patentable due to dependency on claim 18.

In addition, claim 21 is separately patentable. The claim calls for storing the direct leaf in a direct table entry including a search control block and a pattern to be compared. Graphic representation and description of this feature are in Figure 7 and at page 38, line 19 through page 39, line 3. Appellants' specification.

The algorithm for processing the Longest Prefix Match (LPM) is set forth –in part– at page 40, lines 12-21, appellants' specification. Even though the algorithm is not part of the appeal its operation is necessary to fully understand benefits of placing direct leaf in entry of the Direct Table (Fig. 7). In order to access an entry in the Direct Table bits from the input key is used to select an entry. Appellants specification, page 40, lines 17-19. As is shown in Figure 7 with the leaf in the Direct Table the required information is obtained instantaneously. Therefore, this feature reduces delay associated with a search.

With respect to the Examiner's argument –Final Office Action, paper #19, page 6– supporting rejection of claim 21, appellants contend Bremer does not teach a Direct Table. So there would be no need or reason to teach placing a direct leaf in an entry of the Direct Table. As a consequence the feature of appellants' claim 21 has no relevancy in Bremer.

Furthermore, the Examiner relied on teachings at Bremer, col. 8, lines 1-15 and col. 11, lines 22-48, to support the rejection. The referenced teachings relates to "tree walk" algorithm or methodologies. In contrast, the structure of claim 21 eliminates the need for "tree walk". As a consequence the teachings in Bremer are not relevant and possibly "teach away" from claim 21.

K. Patentability of Claim 22

Claim 22 stands or falls with claim 14.

L. Patentability of Claim 23

Claim 23 is patentable because of dependency on claim 14.

In addition, claim 23 is separately patentable. The claim calls for the Pattern Search Control Block to have a shape defined by a width of one, a height of one and is stored in a memory that has a line length of at least 64 bits.

This information enables a designer to select the best type of storage to optimize a design. Other reasons and benefits for this feature are set forth at page 32, line 21 through line 4 and page 39, lines 4 through 15. The benefits and novel structure are evidence of nonobviousness.

The Examiner's reliance on teachings at Bremer, col. 6, lines 30-51 and col. 8, lines 1-15 –Final Office Action, Paper #19, page 6– to support the rejection appears misplaced; since the referenced portions relate to format of data packet (col. 6, lines 30-51) and procedure for traversing a radix tree, respectively. None has any relation to "shape" as claimed and the Examiner gives no reason why an artisan would use the non-related material of Bremer to render claim 23 obvious. As a consequence appellants argue the invention of claim 23 is different from teachings of the reference. Alternately, the Examiner has failed to make out a prima facie case of obviousness. In either situation claim 23 is patentable over the art of record.

M. Patentability of Claim 24

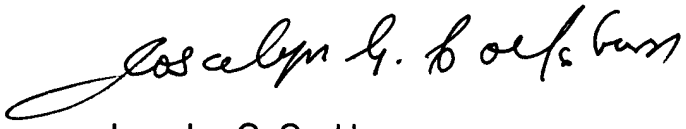
Claim 24 is patentable due to dependency of claim 14.

In addition, it is separately patentable for reasons set forth in L. above and incorporated herein by reference. Like claim 23, claim 24 relates to Pattern Search Control blocks with geometry different from claim 23 yet still provide information for optimizing a design.

CONCLUSION

Based upon arguments set forth herein, the appealed claims define patentable subject matter and are not made obvious by the cited prior art. As a consequence the final rejection of claims 14-24 should be reversed.

Respectfully submitted,



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Appendix of Rejected Claims:

14. A computer readable medium containing a plurality of data structures for finding a longest prefix match for a variable length search key, comprising:

an input key that is to be searched;

a direct table that stores a first address location for a search tree;

a plurality of pattern search control blocks that each represent a branch in the search tree;

at least one bird representing a partial match of the input key; and

a plurality of leaves wherein each leaf is an address location for the result of a search.

15. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 14 further comprising a lookup definition table that manages a tree search memory.

16. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 15 wherein the lookup definition table comprises entries that define a physical memory that the tree resides in, a size of the key and leaf, and a type of search to be performed.

17. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 15 wherein the lookup definition table is implemented in a plurality of memories.

18. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 14 wherein a format for a direct table entry includes at least one of a search control block; a next pattern address that point to a next pattern search control block; a leaf control block address that points to a leaf or result; a next bit or bits to test; and a direct leaf.

19. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 14 wherein a format for a pattern search control block includes at least one of a search control block; a next pattern address that point to a next pattern search control block; a leaf control block address that points to a leaf or result; and a next bit or bits to test.

20. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 14 wherein a leaf data structure includes at least one of a leaf chaining pointer; a prefix length; a pattern to be compared to the search key; and variable user data.

21. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 18 wherein the direct leaf is stored directly in a direct table entry and includes a search control block and a pattern to be compared to a search key.

22. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 14 wherein a pattern search control block is inserted in the search tree at a position where the leaf patterns differ.

23. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 14 wherein a pattern search control block has a shape defined by a width of one and a height of one and is stored in a memory that has a line length of at least 64 bits.

24. The computer readable medium containing a plurality of data structures for finding the longest prefix match of claim 14 wherein a pattern search control block has a shape defined by a width of one and a height of two and is stored in a memory of at least 36 bits.